METHOD FOR INSPECTING CHANNEL PIPES

The invention relates to a method for inspecting pipes such as sewer pipes, pipelines, etc.

EP 1022553 b1 discloses a dolly displaceable within a channel pipe and which is set up for producing fully spherical images at defined path sections along the pipe axis (e.g. every 5 cm) using wide-angle lenses, particularly fisheye lenses. The digital image signals are stored and can be optically evaluated at a later time. US 5,185,667 discloses a method for producing perspective images with swivelling, tilting, rotating and magnification functions from digital images produced with a fisheye lens and permitting an observation of the images taken at the shooting point in different directions, but only as from said point.

Using this method for reproducing exposures of individual images at different locations in the channel pipe, by a suitable calculation of the image signals obtained, it is possible to consider any pipe wall location, but only from the discreet locations where the exposures were made. On performing the dolly travel through the channel pipe or sewer, the image jumps from exposure location to exposure location. However, it is desirable during the subsequent virtual passage through the sewer to give the impression of an actual passage, i.e. to reproduce images from locations where in fact no exposure was made.

On the basis of discreet, hemispherical or fully spherical images recorded at clearly defined path sections of the pipe, the problem of the invention is to simulate a continuous, axial sewer inspection journey, i.e. producing perspective images at random locations outside the optical centres of the exposures taken.

According to the invention this problem is solved by the features of the main claim, whilst the subclaims give advantageous developments of the invention.

The invention makes use of the fact that in the case of pipe systems having a geometry (dimensions and profile) and camera location within the pipe being approximately known, it is possible to calculate from discreet images at clearly defined path sections (e.g. every 5 cm) continuous views along the pipe axis, which are between the actual original exposures.

Starting from the location of the camera in the pipe, for this purpose image data of the hemispherical or fully spherical images (one or two fisheye exposures) are computanionally projected onto the inner surface of the known pipe geometry and use is mathematically made of an infinitely long, three-dimensional pipe model. For each image point of the 2D-fisheye image P (Xf,

Yf) with known imaging function (e.g. F-theta lens) are calculated the angle of incidence (α, θ of the spherical coordinates) and from this a corresponding image point in 3D-space P' (Xr, Yr, Zr) on the pipe inner surface. Such a 3D-scene can be built up for each location of the original exposures within the computer memory. Using known 3D graphic visualization techniques, it is possible to produce a two-dimensional, perspective view. Besides swivelling, tilting, rotating and magnifying functions this also permits a translation (i.e. the simulation of an axial movement through the pipe at locations other than those of the original exposures).

If the fictive camera is now in the vicinity of a nearest original exposure, a new 3D-scene is built up with said exposure. The range of validity of a scene consequently corresponds to the spacing of the discreet original exposure centres.

In order to reduce the data quantity to be calculated (number of image points), it is also possible in the actual scene to only calculate from the desired, fictive camera position and its viewing angle in space the image point located in the desired section (region of interest) of the image plane B of the fictive camera. With the aid of a projection centre, calculation firstly takes place from the image point coordinates of the image plane B the corresponding image point coordinates on the inner surface of the known pipe geometry and from this the corresponding image point coordinates in the fisheye exposure and in this way is obtained the colour and brightness value of the image point on image plane B with P'' (Xb, Yb) = P (Xf, Yf). The necessary mathematics are known to the expert (trigonometry and geometry of space).

Thus, figuratively speaking, the invention is based on the idea of projecting images recorded by the fisheye lens and starting from the recording location, onto the inner surface of an imaginary pipe and observing same after conversion from a random, progressing location into central perspective images.

The invention is described in greater detail hereinafter relative to the attached drawings, wherein show:

Fig. 1   A diagrammatic representation of the calculation of the intermediate images.

Fig. 2   The image plane of the fictive camera.

Fig. 3   The fisheye image.

The following data are placed or are to be placed beforehand in the computer

(computer program):

- The pipe profile and its dimensions (e.g. circular profile with DN, or eye profile with dimensions), position of the fisheyes and angles of the optical axes thereof in the pipe.

- Focal length of the fisheye and its imaging function (F-theta distortion), position, focal length, swivelling, tinting and rotation angle of the fictive camera.

For simplification purposes fig. 1 only shows beams and coordinates on the Y-Z plane. The image plane B of the fictive camera is tilted upwards (not rotated and not swivelled). The optical axes 14 of the fisheye lenses 10, 12 correspond to the pipe axis.

B = fictive camera image plane,

F = fictive camera focal length (spacing of the image plane B or projection plane from the optical centre of the fictive camera or projection centre),

α, θ = angle of incidence in fisheye, θ being the angle to the Z-axis and α the angle formed by the beam projection on the X, Y plane with the X axis,

(Xb, Yb) = image point coordinates on the image plane B,

(Xr, Yr, Zr) = image point coordinates on the pipe wall,

P" (Xb, Yb) = P (Xf, Yf).

The image point coordinates (Xf, Yf) in the F-theta fisheye image are calculated from the angles of incidence θ and α with:

$Yf = \sin(\alpha) * Ff * \theta$ and $Xf = \cos(\alpha) * Ff * \theta$,

in which Ff = focal length of fisheye lens.

In fig. 1 the following applies:

$\alpha = Pi/2 \rightarrow Xf = 0$ and $Yf = \theta$.

In fig. 1 it is assumed that at specific locations 18 within the pipe to be inspected a fisheye lens 10 makes forwardly directed exposures and another fisheye lens 12 rearwardly directed exposures. From a fictive camera

position 16 between the locations 18 where the original exposures were made, are acquired scenes built up as from the locations where the original exposures were made.